

# *Sensors for Chem/Bio Defense* *- A Survey -*

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# *Agenda*

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- **Overview**
- **Operational Needs**
- **Current System Requirements for Sensors**
- **Active Research**

# *Acknowledgements*

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# Overview

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- Three classes of sensor information:
  - detection
  - localization
  - classification
- Multiple robust solutions for chemical sensors
  - Point - Manual** - colorimetric paper; enzymatic-substrate based wet chem; ionization product diffusion;
  - Point - Automated** - electrochemical; single-cell/dual cell ion mobility spectrometry; baffle tube ionization cells;
  - Standoff/Early Warning** - forward looking infrared technology (FLIR); passive, Fourier transform infrared (FTIR) spectrometry;

## Overview, Continued

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- Current bio identifiers rely on detailed laboratory analysis
  - assays
  - electron and oil immersion microscopy
- Limited, but promising future solutions for biological sensors
  - Point - Manual** - flow cytometry; ATP luminescence; UV aerodynamic particle sizer; mass spectrometry;
  - Standoff/Early Warning** - LIDAR
- Detection based on features of biological activity i.e. tryptophan for bacteria
- Biological characterization requires (to date) fusion of information
  - \* particle #
  - \* size distribution
  - \* base pair constitution and sequence

## *Operational Needs*

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**Enhanced detection, identification, mapping and confirmation of any standard/non-standard hazards including toxic industrial materials (TIMS).**

**Immediate notification of hazard existence/location.**

**Automated identification, plotting and hazard density mapping over time.**

**Obtain and preserve hazard samples.**

- **Point, aerial, shipboard (multiple platforms) and large area coverage.**
- **Water test capability.**
- **Integrated point and remote/early warning.**
- **Interface with joint C4I architecture.**

# *Current Systems*

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# *Chemical Vapor Detector Requirements*

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- + Small Lightweight (pocket size)**
  - + Immediate detection time (seconds)**
  - + Low maintenance**
  - + Broaden from chemical agents to environmental**
- 
- Immediate cleardown time (seconds)**
  - No hazardous internal sources**
  - Inexpensive**
  - Ability to be networked**
  - Short term (days) memory; long term download for historical record**
  - Flexibility in applications**
  - Ability to learn (neural)**

# *Chemical Water Monitor Requirements*

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- + No false alarms**
- + Detect ppb/ppt levels of CB agents and their hydrolysis sentinel compounds in source, treated, distributed and discharge water**
- + In-line continuous and batch ( $\leq 10$  minutes) detection and quantification**
  - Low power, light weight, inexpensive**
  - Upgradeable, prefer no disposables, few moving parts, easy to maintain and use**
  - Modular system**

# *Joint Chemical Agent Detector (JCAD)*

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## OPERATIONAL CONCEPT

- Detect point and cumulative exposures of CW agents.
- Compatible with the Joint Warning and Reporting Network (JWARN).
- Operate from a variety of platforms to support contamination avoidance or reconnaissance.



- Nerve and Blister Agent Detection
- Lightweight and Portable
- Expandable for Emerging Threat Agents
- Mass Spectrometry
- GC/SAW Combination
- Paper Size

## CAPABILITIES REQUIRED

- Detect, ID and quantify nerve, blister and blood agent vapors.
- Liquid, particulate, specific agents and TIMs are objective requirements.
- Minimize false alarms (MTBFA > 168 hours).
- Capable of rejecting battlespace interferants.
- Will not exceed two (2) pounds and forty (40) cubic inches.

# *Biological Aerosol Detector Requirements*

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- + Sensitive to bacteria (20,000 cfu/ml), viruses ( $1 \times 10^7$  pfu/ml), toxins (1 ng/ml)**
- + Rapid detection**
- + Minimal setup time (zero to 1 minute)**
- Small, lightweight and ruggedized**
- Low maintenance**
- On-board filtration/eliminate interferents and dust**
- High specificity without loss of sensitivity**
- Fully automated; no skill required to operate**
- Long operation time and ability to be networked**
- Short term memory (days); long term download for historical record**
- Flexibility of applications**
- Adaptable to new threats**

# *Biological Water Monitor Requirements*

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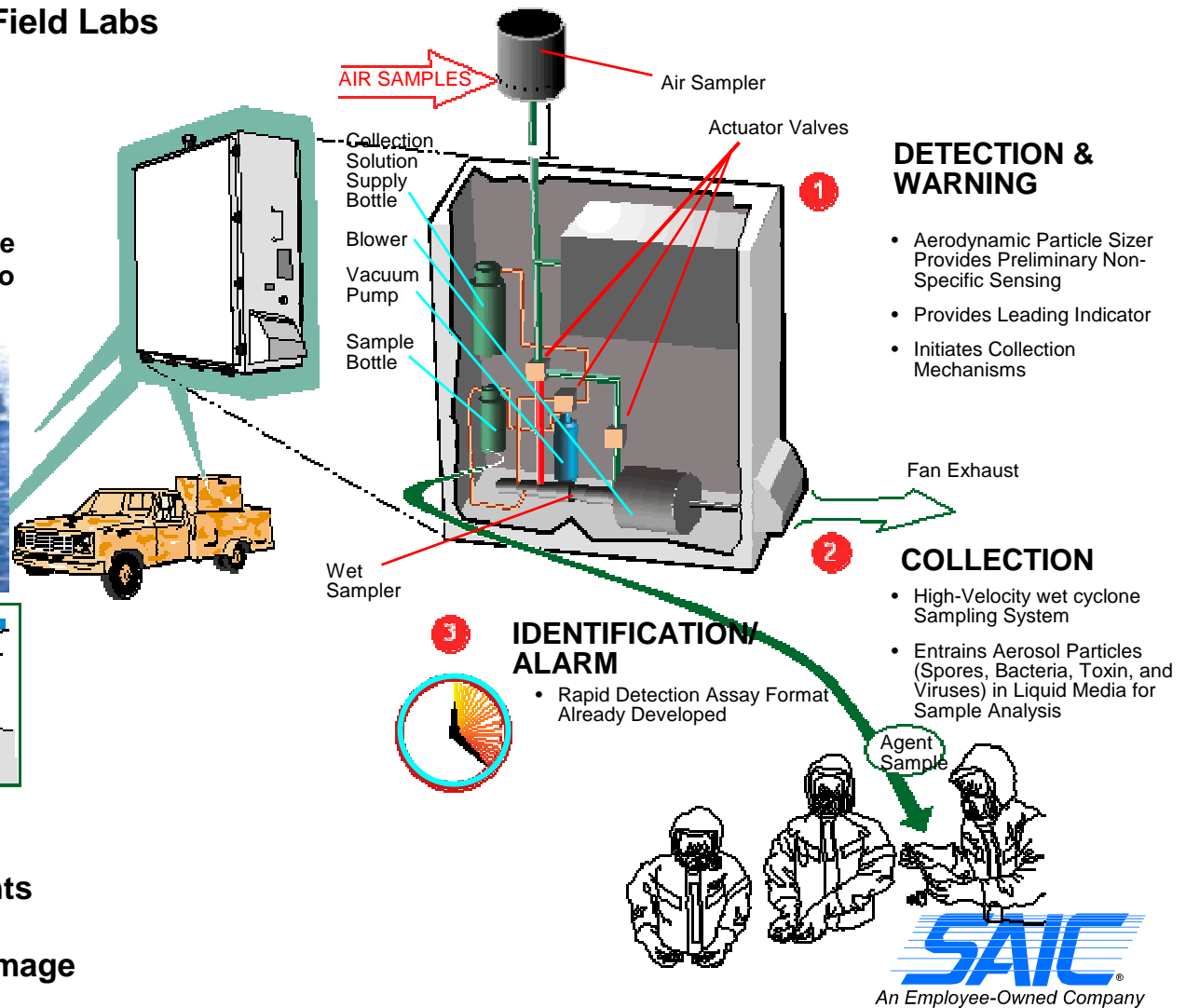
- + Sensitive to bacteria (20,000 cfu/ml), viruses ( $1 \times 10^7$  pfu/ml), toxins (1 ng/ml)**
- + Adaptable to any water sampler**
- + Rapid detection**
- + Adaptable to new threats**
- Small, lightweight and ruggedized**
- On-board filtration/eliminate organic and inorganic interferents**
- High specificity without loss of sensitivity**
- Minimal setup time**
- Fully automated; no skill required to operate**
- Long operation time and ability to be networked**
- Short term memory (days); long term download for historical record**
- Flexibility of applications**

# Interim Biological Agent Detector (IBAD)

**Yesterday** - Only Forward Field Labs

**Today** - IBAD Can Provide:

- Immediate Capability to Support Contingency Force Deployments
- Responsive in Sea and Land Environments
- Full Detection Capability on the Move
- Timely Threat Warning Notification to Force Command and Control



**In the Future---**

- Expansion for Additional Agents
- Increased Automation
- Integration with Shipboard Damage Control System

# *Joint Service Warning and Identification Lidar Detector (JSWILD)*

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## OPERATIONAL CONCEPT

- Provide a laser standoff integrated chemical and bioaerosol detection capability for protection of fixed sites, ships, and possibly for recon.
- standoff CB detection of aerosols/rains/particulates/liquids in addition to vapors, in real time
- 20 km range and precise ranging information.



## CAPABILITIES REQUIRED

- Max Range: 10 km now, 20 km in 2000
- Provides precise location of threat
- Vapor (nerve): 20 mg/m<sup>2</sup>
- Vapor (blister): 500 mg/m<sup>2</sup>
- Aerosols/rains: 20 mg/m<sup>2</sup> or less
- Surface prediction: 0.01 g/m<sup>2</sup>
- Bioaerosol detection, discrimination?
- 99.6% probability of detection
- detects in a few seconds or less (real-time)

# *Technological Progression*

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## **DESERT STORM**

### **Chemical**

- M8/M9 Paper
- M256A1 Kit
- M8A1 CW Alarm
- M272A1 Water Kit
- CAM
- CAPDS
- M21 RSCAAL
- AN/KAS-1

### **Biological**

- ➔ SMART tickets

## **TODAY**

### **Chemical**

- IPDS
- ICAM
- SALAD
- ACADA
- M93A1 NBCRS

### **Biological**

- IBAD
- BIDS
- Portal Shield
- LR-BSDS

\* including all Desert Storm Capabilities

## **FUTURE**

### **Chemical**

- JSLSCAD
- JCAD
- JCBAWM
- JSWILD

### **Biological**

- JBPDS
- JBSDS

### **NBC Infrastructure**

- JSLNBCRS
- JWARN



# System Capabilities - Today

Systems*	CHEM	BIO	Point	Stand-off	Portable	Low Maint.	Easy to use	Low Cost	Sensitivity	Low FAR	Multi-Agent	Auto Warn	Networked	Response Time	Auto Agent ID	Range	Tracking	Large Area
M8,M9 Paper																		
M256A1 Kit																		
M272 Water																		
AN/KAS-1																		
M21 RSCAAL																		
M8A1																		
ALAD																		
ACADA																		
ICAM																		
ICAD																		
CAPDS																		
IPDS																		
BIDS																		
IBAD																		
LR-BSDS																		
M93-NBCRS																		

\* See list of System Definitions



Limited or N/A



Applicable and Adequate

# Future Systems Capabilities Objectives

Systems*	CHEM	BIO	Point	Stand-off	Portable	Low Maintenance	Easy to use	Low Cost	Sensitivity	Low FAR	Multi-Agent	Auto Warn	Networked	Response Time	Auto Agent ID	Range	Tracking	Large Area
SALAD																		
JCAD																		
JCBAWM																		
JSLSCAD																		
JBSDS																		
JSLNBCRS																		
JBPDS																		
JWARN																		

\* See list of System Definitions



Limited or N/A



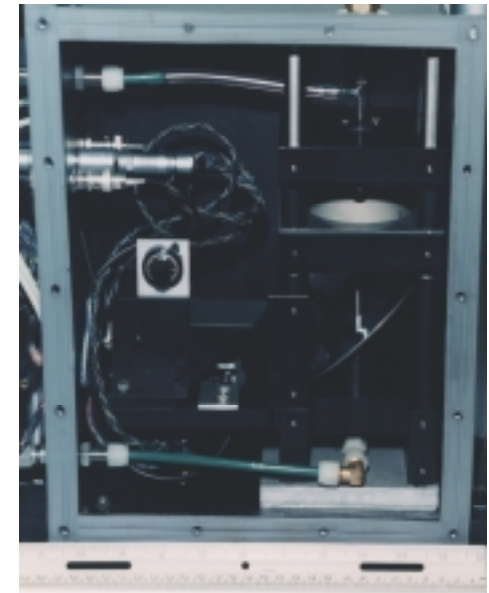
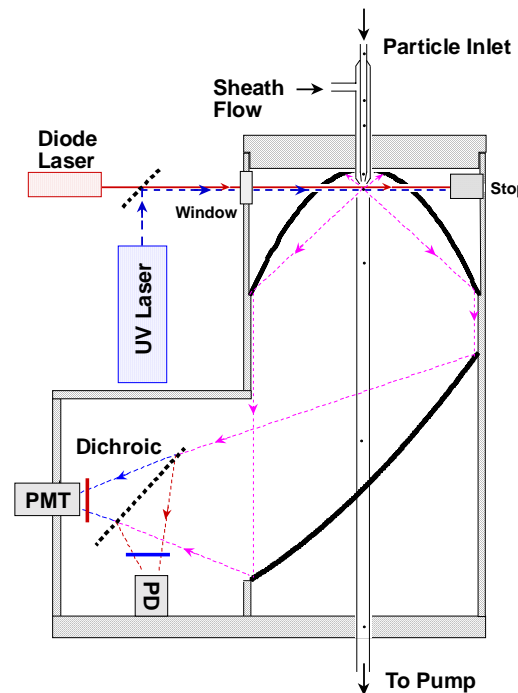
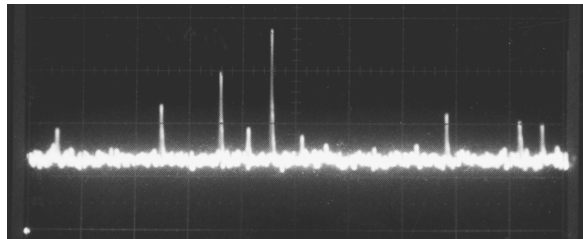
Applicable and Adequate

# *Future Directions and Issues*

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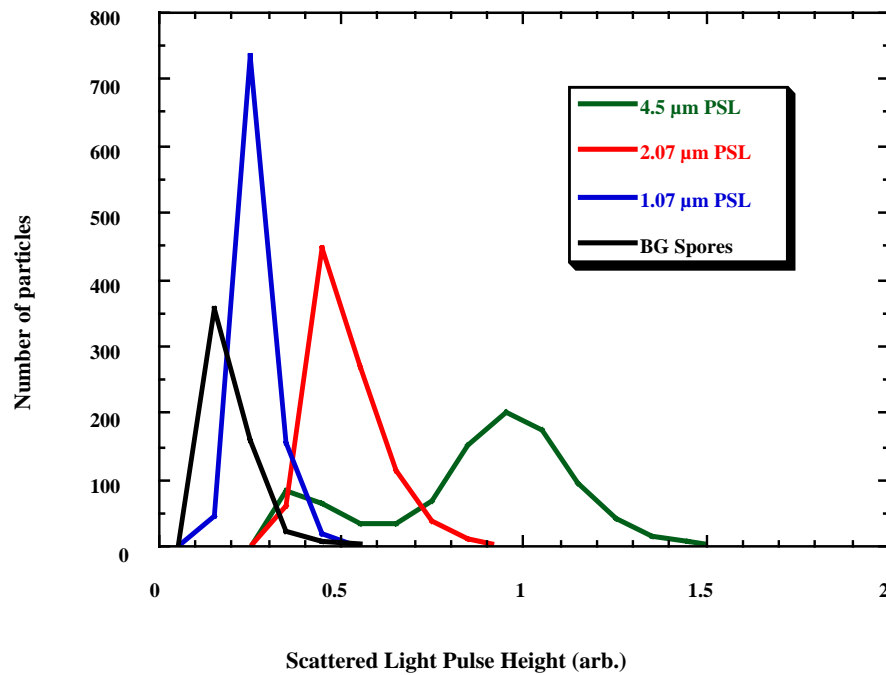
# Single Particle Fluorescence - Detection Operation (Siever, NRL)

- Particles cross red beam & scatter light. Pulses are proportional to particle size and also trigger the UV laser
- 1  $\mu$ sec later, UV laser excites the particle. Its fluorescent intensity indicates particle composition
- Scattered and fluorescent pulse heights are captured in data record.

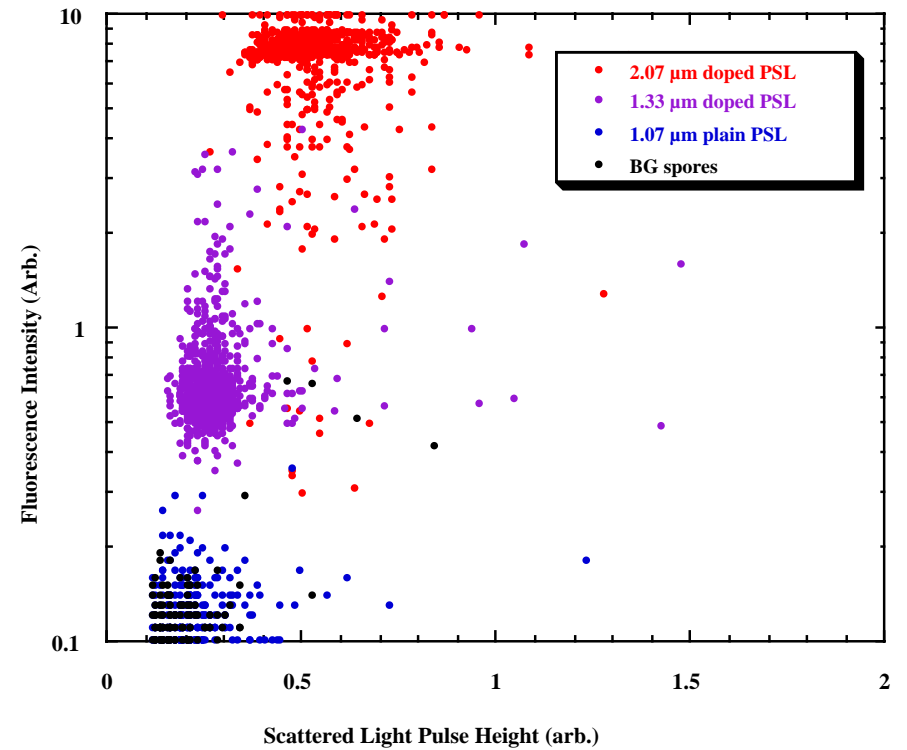


# Calibration with PSL

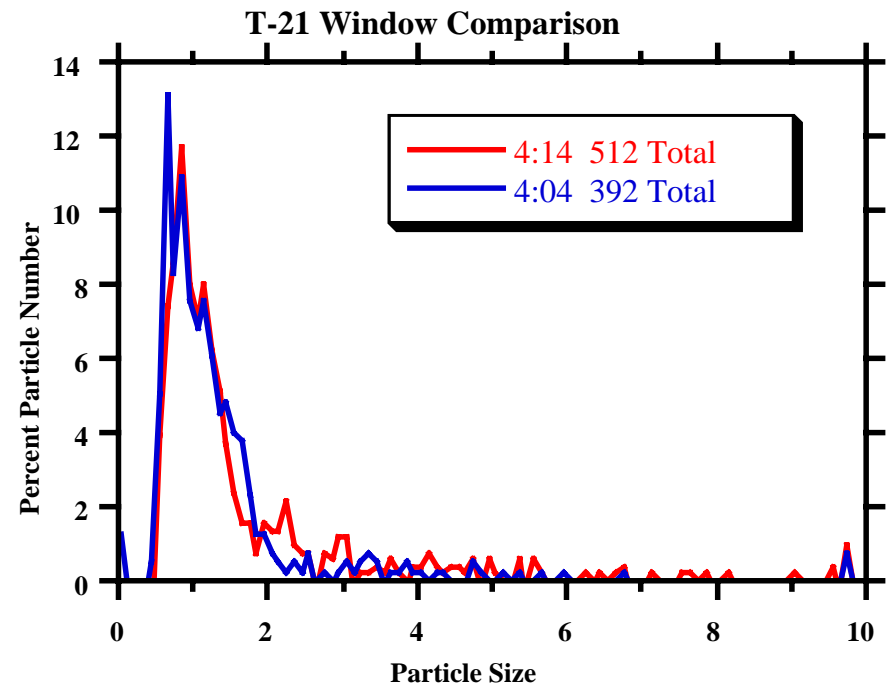
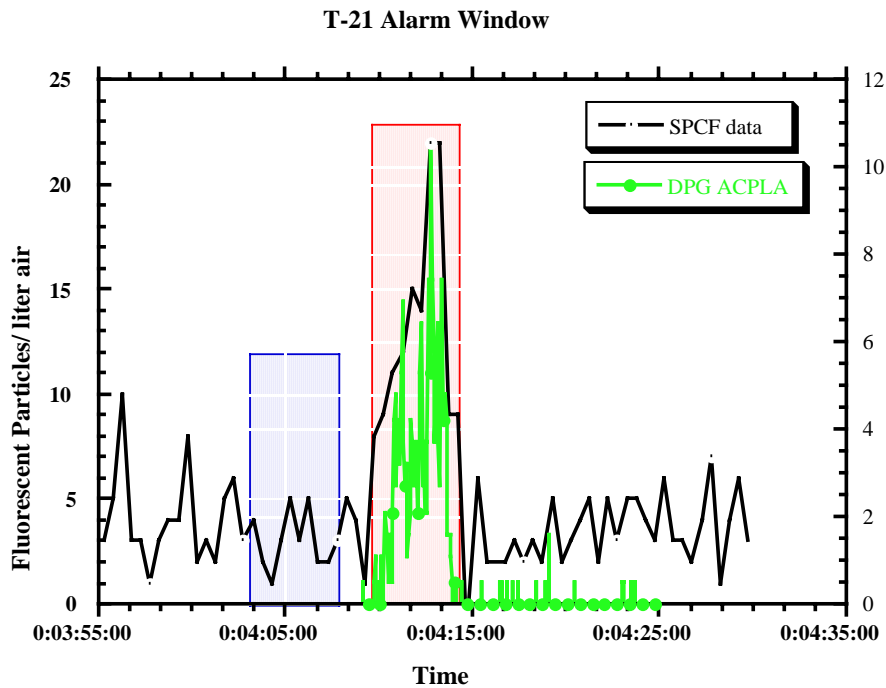
Size Calibration



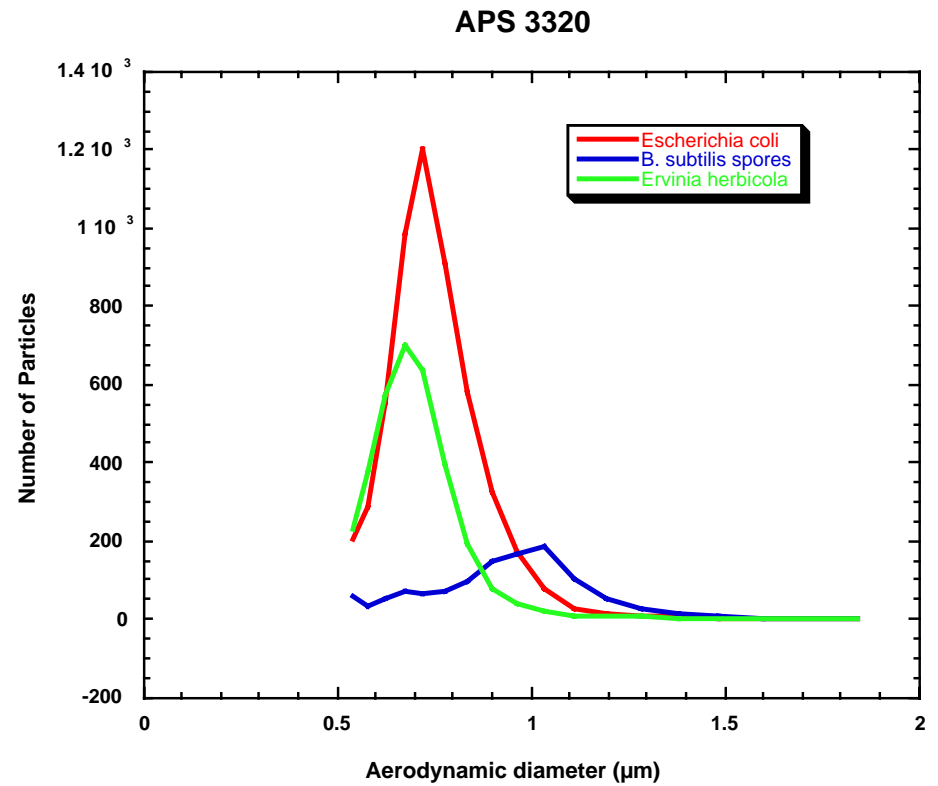
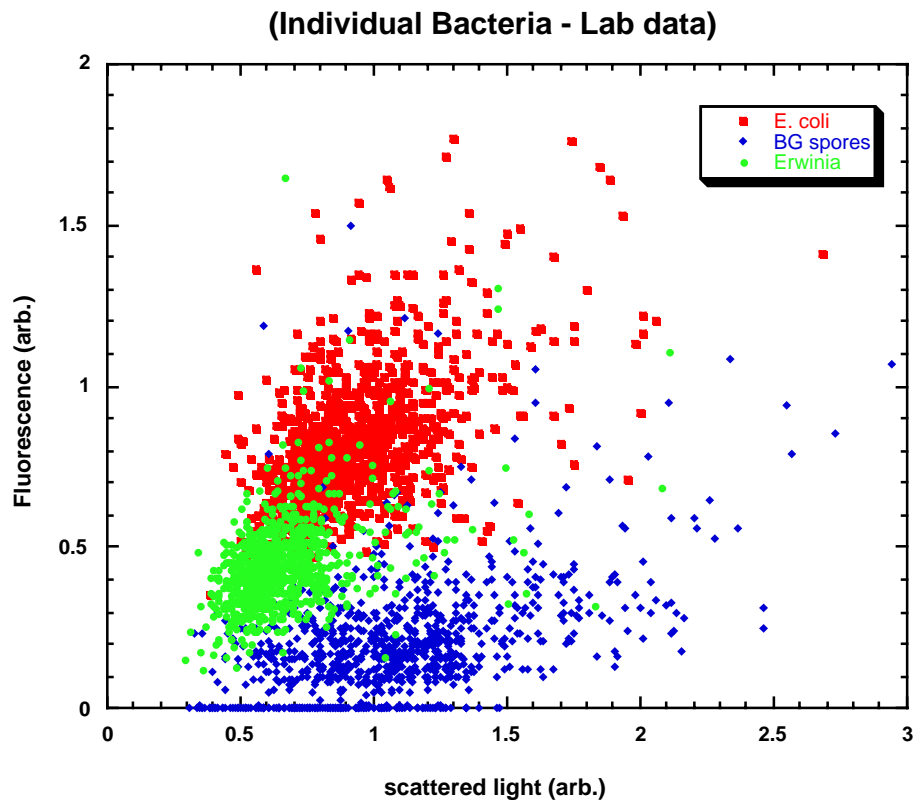
Fluorescence Calibration



# *Fluorescence with Particle Number Fusion*

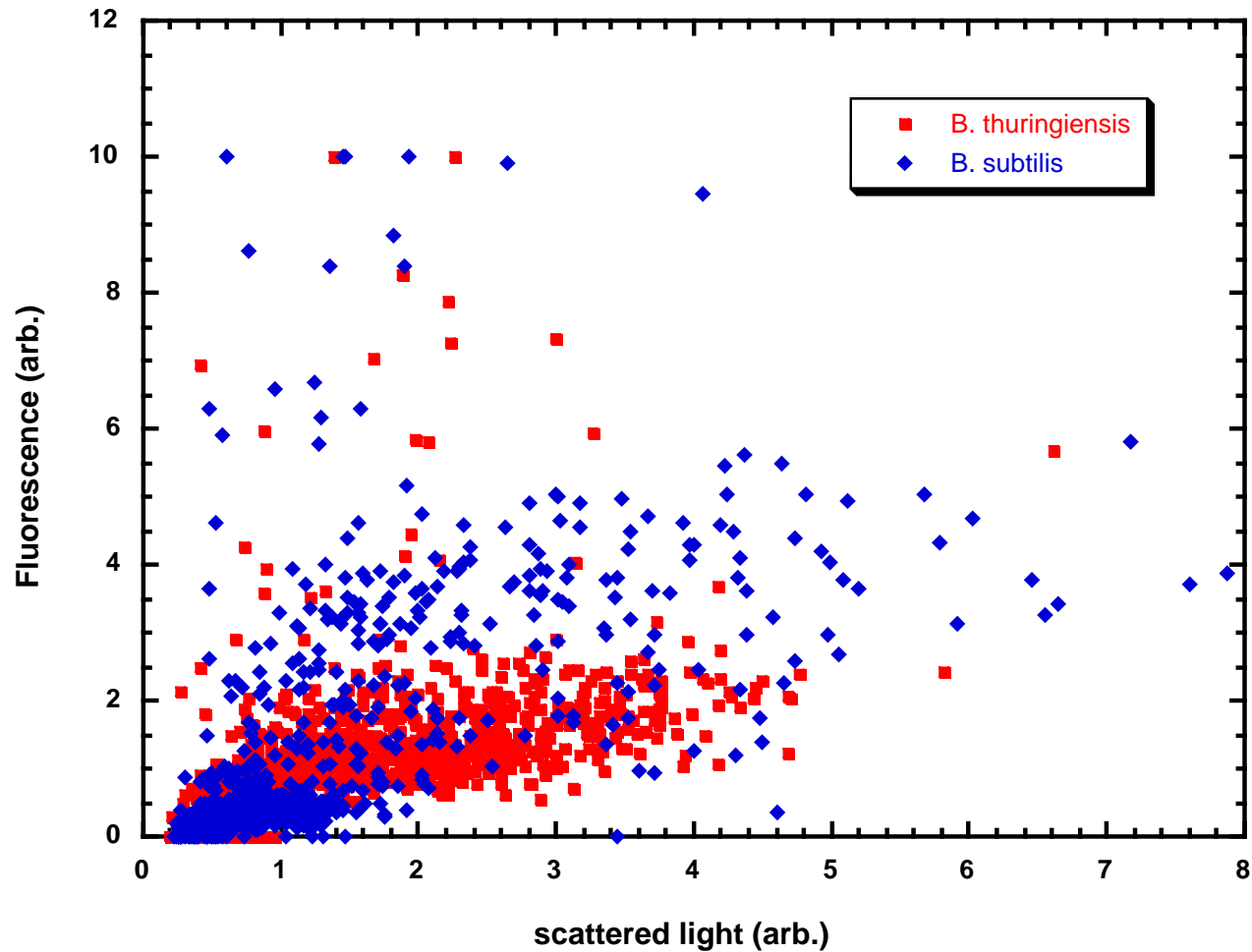


# Calibration with Bacteria



# *Bacterial Fluorescence Comparison*

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**SAIC**  
an Employee-Owned Company

## *Conclusions*

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- Lasers have been employed for detection (point ® limited range)
- Lasers have been used for gross features determination
- Gene-oriented characterization techniques are current research rage for rapid characterization
- Novel active (laser) ideas are ...